SECTION 3
FIELD INVESTIGATION

3.1 INTRODUCTION

3.1.1 The field investigation was conducted at the 323-acre wooded site between September 1998 and May 1999 to determine the nature and extent of OE contamination here. The site is recognized by DOD as being eligible for cleanup funding under the BRAC program.

3.1.2 The field investigation was comprised of two separate efforts – the geophysical survey and the intrusive investigation. The geophysical survey was conducted between September 7 and September 11, 1998 by GEO-CENTERS, Inc. under direct contract to USAESCH. The intrusive investigation was conducted between May 8 and May 13, 1999 by Parsons ES. The information gathered from these efforts was used to determine the most appropriate response action to address the safety risk posed by UXO at the site.

3.1.3 Based on the data collected during the intrusive investigation, alternatives will be identified and developed to address the safety risk posed by UXO exposure at the site. This section presents a description of the field investigation activities, the field investigation results, and a discussion of the type of OE recovered during the intrusive investigation.

3.2 GEOPHYSICAL SURVEY

3.2.1 Introduction

3.2.1.1 A geophysical survey to detect ferrous metal objects was conducted at the site between September 7 and September 11, 1998 by GEO-CENTERS, Inc. under direct contract to USAESCH. GEO-CENTERS used the Portable Surface Towed Ordnance Locator System (Portable STOLS$^{?}$) during the geophysical survey.

3.2.1.2 Field activities conducted during the geophysical survey included the following tasks:

?? establishing the Global Positioning System (GPS) local base station;
?? standardizing the Portable STOLS® magnetometer(s); and
?? geophysically surveying the site.

3.2.1.3 A review of the historical records pertaining to JPG and the results of previous field investigations performed on other portions of the facility led to the specific locations for the pseudo-random walk geophysical survey in the site. The results of the OE clearance investigations conducted on other portions of JPG are discussed in Section 2 of this report. According to the historical record, the National Guard used the former airfield (located east of the site) for training with practice mortars and rockets. The southern portion of the site was suspected to be an area where over shot rounds may have impacted. During the OE clearance activities of the airfield, OE items were recovered from the area east of Tokyo Road as well as in the area immediately north of the site. OE items recovered from these areas included fuzed 60mm and 22mm mortar rounds.

3.2.2 Survey Control

Prior to conducting the geophysical survey, two GPS monuments were laid out by a Registered Land Surveyor provided by Civil Design Services, Inc. Each of the two monuments were established with reference to existing local survey control points and referenced to the Indiana State Plane Grid System. The monuments were marked by setting a properly labeled brass disk in concrete. Additional details on the locations and construction of the monuments are contained in GEO-CENTERS' report, which is included as Appendix B.

3.2.3 Geophysical Survey Instruments

3.2.3.1 Two types of geophysical survey instruments were used by the geophysical survey contractor during the field investigation. These instruments included the Portable STOLS® and Schonstedt magnetometers. The Portable STOLS® is a magnetometer-based system developed by GEO-CENTERS to rapidly acquire high-density magnetic data over an area of interest. The system consists of two total field cesium vapor magnetometers (Geometrics Model 822A) mounted 0.5 meters apart on a composite frame along with a GPS mounted directly above the right hand magnetometer. Both the Portable STOLS® and the GPS data acquisition system are embedded in an aluminum backpack which holds a computer and custom sensor interface that sampled the data from the magnetometers at 20 Hz and the GPS

receiver every second. A GPS base station was set up in the vicinity of the northern survey monument to measure the diurnal variations of the earth's magnetic field every 15 seconds. This data was used to correct the locations of the survey data collected during the geophysical survey.

3.2.3.2 During the intrusive investigations, GEO-CENTERS was tasked by USAESCH to reacquire the selected target locations using the GPS and to verify the target reacquisition with a Schonstedt Model GA-52Cx magnetometer. This instrument is a passive fluxgate-type magnetometer designed to detect ferrous metal objects. The instrument consists of a handheld wand with an audio response to signal the detection of ferrous metal objects. The instrument responds to the difference in the magnetic field between two sensors spaced approximately 20 inches apart within the body of the instrument. The Schonstedt does not provide a digital measurement of its readings nor is it linked to a positioning system that can record the location of the anomalies in a data logger. These instrument limitations, however, did not prove to be a detriment in its application during this project. Several of the target locations could not be verified in the field with the Schonstedt but were marked at the reported GPS coordinates. These targets are referred to as non-verifiable throughout the document.

3.2.4 Equipment Standardization

3.2.4.1 The geophysical survey equipment was standardized by GEO-CENTERS through the construction of a test plot located in the vicinity of the northern survey monument. The test plot consisted of a single east/west line approximately 100 feet (30.48 meters) long with three targets placed on the surface along the path. The targets consisted of the following items:

- Target #1 was a 1.25-inch diameter pipe, 24 inches long, which was located at the 25 foot mark of the prove-out plot. This pipe was oriented north/south.
- Target #2 was a 2.0-inch diameter pipe, 8 inches long, which was located at the 50 foot mark of the prove-out plot. This pipe was also oriented north/south.
- Target #3 was a 1.25-inch diameter pipe, 24 inches long, which was located at the 75 foot mark of the prove-out plot. This pipe was oriented east/west.

3.2.4.2 The Portable STOLS® was then traversed along the test plot and the data was collected and analyzed in the same manner as the survey data collected during the

geophysical survey. All three targets were detected by the Portable STOLS? and the system was determined to be operating as designed.

3.2.5 Geophysical Survey

3.2.5.1 The 1998 geophysical survey was described as a "pseudo-random walk" over the site ("pseudo" because the site was surveyed with a series of parallel lines; "random" because the team followed the path of least resistance when traversing the survey lines). The geophysical survey crew consisted of three personnel. A UXO specialist was the first person on the team to traverse the area, followed by the Portable STOLS® operator and then a support team member. The UXO specialist provided UXO avoidance support and maintained a general east/west direction to the survey lanes. The Portable STOLS® operator ensured continuous operation of the equipment during the survey and collected the geophysical and positioning data. The support team member provided support by carrying reserve batteries, drinking fluids, and other support equipment.

3.2.5.2 As described in Section 2, the site was divided into two parcels for the field investigation, including a larger parcel of approximately 312 acres and a smaller parcel of approximately 11 acres. During the geophysical survey, 14 survey lines, totaling approximately 5.84 lane-miles, were walked within the larger parcel and seven survey lines, totaling approximately 1.28 lane-miles, were walked within the smaller parcel. All lines were walked in a general east/west orientation. Figure 3-1 illustrates the locations of the pseudo-random walk geophysical survey lines in both parcels.

FIGURE 3-1
Pseudo-Random Walk Geophysical Survey Lines

3.2.6 Survey Area Coverage

The geophysical survey area coverage was determined by measuring the number of lane-miles walked during the geophysical survey, converting this number to lane-feet by multiplying by 5,280 (the number of feet in a mile). This product was multiplied by 3.28 feet (1 meter), the width of the survey lane swept by the magnetometers. This product was then divided by 43,560 (the number of square feet in an acre). From these calculations the total area geophysically surveyed at the site was determined to be approximately 2.83 acres. Since the site consists of approximately 323 acres, the geophysical survey covered approximately 0.87% of the entire area of investigation. Tables 3.1 and 3.2 provide a break-down of the lane-miles walked, acreage geophysically surveyed, and per cent of area geophysically surveyed for the 312-acre and 11-acre parcels.

TABLE 3.1

GEOPHYSICAL SURVEY SUMMARY
312-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Lane-miles walked	5.84
Acres Geophysically Surveyed	2.32
Per Cent of Area Surveyed	0.74%

TABLE 3.2

GEOPHYSICAL SURVEY SUMMARY
11-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Lane-miles walked	1.28
Acres Geophysically Surveyed	0.51
Per Cent of Area Surveyed	4.6%

3.2.7 Data Processing and Analysis

Upon completion of the geophysical survey in the field, the collected data was transferred to a computer workstation for processing and analysis. The magnetometer data was referenced to the data collected by the GPS so that the locations of the geophysical anomalies could be identified. Next, the locations of the identified anomalies were cross-referenced with the field notes to determine if any known cultural features (e.g., utility lines, observed metallic debris, etc.) could be the source of the geophysical reading. The remaining geophysical anomalies were further analyzed and those anomalies that possessed the characteristics of UXO were selected for intrusive investigation. This analysis resulted in the selection of 89 anomalies for intrusive investigation.

3.3 INTRUSIVE INVESTIGATION

3.3.1 Introduction

3.3.1.1 An intrusive investigation of the suspect anomalies identified from the geophysical survey was conducted at the site between May 8 and May 13, 1999. The purpose of the intrusive investigation was to identify, remove, and document the metallic objects that caused the signal on the Portable STOLS® magnetometer during the geophysical survey. USAESCH contracted with Parsons ES to perform the intrusive investigations, while GEO-CENTERS reacquired the anomalies that were selected to be intrusively investigated under their original contract with USAESCH. The intrusive investigation was conducted concurrently with the reacquisition activities. Figure 3-2 illustrates the locations of the 89 anomalies selected for intrusive investigation.

3.3.1.2 The intrusive investigation of the site included:

- ?? reestablishing GPS survey control in the area;
- ?? reaccquiring the geophysical anomalies selected to be intrusively investigated; and
- ?? conducting the intrusive investigations on the selected geophysical anomalies to determine their nature.

FIGURE 3-2

Anomalies Location Map

3.3.1.3 At the beginning of the intrusive investigation, a kick-off meeting was held with representatives from all parties involved in the field effort. Topics covered during the kick-off meeting included the scope of services to be conducted, the establishment of a safety exclusion zone, and traffic control procedures.

3.3.2 Exclusion Zone

A 1200 foot (366 meter) exclusion zone was established around all work zones during the intrusive investigation. This exclusion zone was established to minimize the effects due to fragmentation or over-pressure from an unintentional OE detonation during the intrusive investigation. This zone was observed in accordance with the USAESCH-approved Health and Safety Plan for the project. The establishment of the exclusion zone allowed for only essential personnel within the zone during the intrusive investigations. The exclusion zone was established based on the results of previous OE investigations performed at JPG and using the 60mm mortar round as the Most Probable Munition for the investigation.

3.3.3 Traffic Control

Traffic control was necessary due to the proximity of a public highway (Woodfill Road) to a number of the investigated anomalies. The intrusive investigations were conducted with little or no disruption to local residents or workers. Traffic control was maintained along Woodfill Road by placement of a road guard that advised the UXO team of any oncoming traffic on the road. If the UXO team was in the act of an intrusive investigation, they ceased the activity until the road guard indicated the road was clear.

3.3.4 Intrusive Investigation Procedures

3.3.4.1 All intrusive investigation procedures were conducted in accordance with UXB's previously-approved Work Plan, which had been prepared by them to conduct the UXO clearance operations on other portions of the JPG site. Once a target anomaly was reacquired and marked by GEO-CENTERS, the UXO subcontractor began the intrusive investigation. The identified anomalies were investigated by removing the overlying soil either by hand or shovel. If possible, the item causing the anomaly reading was immediately removed from the area so that it would not interfere with any other intrusive investigations. If no metallic object was found within the first 4 feet (1.2 meters) of soil, the intrusive investigation was considered complete and the area was returned to its original state. The UXO subcontractor

used a Foerster Ferex Ordnance Locator (MK26) during the intrusive investigations to aid in locating the source of the anomaly reading. The MK26 is a hand-held unit incorporating two flux-gate magnetometers which are aligned and mounted a fixed distance apart within the body of the instrument to detect changes in the earth's ambient magnetic field caused by ferrous metal or disturbances caused by soil conditions.

3.3.4.2 The UXO team performed an Explosive Ordnance Reconnaissance (EOR) on all magnetic anomalies excavated. Each anomaly was treated as a suspect UXO until it was determined otherwise. EOR procedures began by identifying the subsurface contact. This identification included conducting a thorough hazard assessment.

3.3.4.3 Any suspect OE items uncovered during the intrusive investigation were analyzed by the Senior UXO Supervisor. OE items that were recovered during the intrusive investigation were handled in one of two different ways. OE fragments were inspected, certified, and transferred to the on-site scrap yard for holding until off site disposal could be arranged at the end of the project. Potentially hazardous OE items were blown in place.

3.3.4.4 Non-OE related scrap recovered during the intrusive investigations was collected and relocated to the on-site scrap area at the end of each day's activities. The non-OE-related scrap was disposed of off-site at the end of the intrusive investigation.

3.3.4.5 Those anomalies that could not be reacquired by GEO-CENTERS using the Schonstedt were marked using the GPS coordinates identified during the analysis of the geophysical survey results. The UXO subcontractor then reswept the area marked by GEO-CENTERS to a radius of 2 meters around the identified anomaly with the Ferex MK26. If no reading was identified by the UXO subcontractor using the Ferex MK26, then the area marked by GEO-CENTERS was intrusively investigated. All anomalies, both verified and non-verified, were intrusively investigated to a depth of 4 feet (1.2 meters) unless the object causing the geophysical reading was located prior to that depth.

3.3.5 Intrusive Investigation Quality Control Procedures

3.3.5.1 Quality Control (QC) procedures were performed at ten of the intrusively investigated targets by UXB's QC Supervisor under the direct observation of the on-site USACE representative. QC procedures consisted of the following:

- ?? selecting the anomalies to be independently checked;
- ?? sweeping the area with a Ferex MK26 magnetometer; and
- ?? recording the resulting information in the project log book.

3.3.5.2 The Ferex MK26 magnetometer was factory calibrated and was operating within its designed parameters. At each target site the area around the excavation was swept with the Ferex MK26 magnetometer to a radius of approximately 10 feet (3 meters). A total of ten non-verifiable anomalies were selected for QC procedures because of the concern for the ability of the Schonstedt to reacquire the selected anomalies. The following anomalies were selected for the QC procedures: A1, A3, 71, 86, 100, 101, 102, 106, 109, and 112. The UXB QC Supervisor indicated that all locations were free of any contacts from the Ferex MK26 for a radius of approximately 10 feet (3 meters) around the identified anomaly location.

3.4 NATURE AND EXTENT OF OE CONTAMINATION

3.4.1 Introduction

A tally of the OE-related and non-OE related items recovered during the intrusive investigations was completed at the end of the investigation. Appendix C includes a listing of the intrusive investigation findings. All 89 anomalies were intrusively investigated. The results of the intrusive investigations conducted at the two parcels are summarized in the following sections including the number of potentially hazardous OE items, OE-related scrap items, non-OE-related scrap items, and negative anomalies that were recorded during the intrusive investigation.

3.4.2 312-Acre Parcel

Table 3.3 summarizes the results of the intrusive investigation conducted in the 312-acre parcel. A total of 55 anomalies were intrusively investigated in this parcel. One potentially hazardous OE item was blown in place and one piece of OE-related scrap was recovered. The locations of these two items are presented in Figure 3-3. A total of 36 pieces of non-OE-

related scrap, consisting mainly of small metal nuggets, barbed wire, and other miscellaneous metallic debris, were also recovered. The intrusive investigations at the 17 non-verifiable locations did not result in any recovery (no contact). Figure 3-4 illustrates the locations of the non-verifiable anomalies.

TABLE 3.3

SUMMARY OF INTRUSIVE INVESTIGATION FINDINGS
312-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Item	# of Items	Percent of Total
Potentially Hazardous OE Items	1	1.8
OE Scrap Items	1	1.8
Non-OE-Related Scrap Items	36	65.5
Negative Anomalies Dug to a Depth of 4 feet (1.2 meters)	17	30.9
Total	55	100

3.4.3 11-Acre Parcel

Table 3.4 summarizes the results of the intrusive investigation in the 11-acre parcel. A total of 34 anomalies were intrusively investigated in this parcel. No OE-related items were found in this parcel. A total of 32 pieces of non-OE-related scrap, consisting mainly of small metal nuggets, barbed wire, and other miscellaneous metallic debris, were recovered. The intrusive investigations at the two non-verifiable locations did not result in any recovery (no contact). The locations of the non-verifiable anomalies are shown in Figure 3-4.

Figure 3-3

FIGURE 3-4

Locations of Non-Verifiable Anomalies

TABLE 3.4

SUMMARY OF INTRUSIVE INVESTIGATION FINDINGS
11-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Item	# of Items	Percent of Total
Potentially Hazardous OE Items	0	0
OE Scrap Items	0	0
Non-OE-Related Scrap Items	32	94.1
Negative Anomalies Dug to a Depth of 4 feet (1.2 meters)	2	5.9
Total	34	100

3.4.4 UXO Calculator Application

3.4.4.1 The USAESCH-developed tool *UXO Calculator* was used to determine the probabilistic UXO density estimate based on the area of each sector, the area sampled, and the number of UXO items found during the field investigation. *UXO Calculator* is based on a negative binomial probability distribution. The negative binomial depends upon only two outcomes – (1) success, meaning that the randomly placed UXO is in the investigated region (occurs with a probability "p"), and (2) failure, meaning that the UXO is not in the investigated region (occurs with a probability "q=1-p"). The model assumes that there is a uniform probability of the occurrence of UXO across the site; however, the model also assumes that the UXO has been randomly deposited across the site. This means that there is an equal likelihood for UXO to fall anywhere within the sector; however, there is not necessarily a uniform distribution of UXO.

3.4.4.2 There are six modules in the *UXO Calculator* Program. These modules include:

?? Sector Expected Density – this module provides the expected density of UXO within a sector given the amount of sampling conducted and the results of the sampling to date;

?? Sector Count Probability – this module provides the probability of a UXO count in a sector (e.g., 90% sure that the UXO count is equal to or lower than 200);

?? Sector Density Probability – this module provides the probability for a test density (e.g., 90% sure that there is less than a 0.5 UXO per acre on average across the sector);

?? Confidence Level – this module provides the number of UXO expected in the sector based on the degree of confidence (e.g., 90% confidence level equals to 200 or less UXO in the sector);

?? Variability of Density Estimate – this module provides both ends of a confidence interval (e.g., 95% confidence with 0 found during the sampling; maximum UXO expected is 233); and

?? Minimum Discrimination – this module provides the probability of finding one or more UXO in an investigated area (e.g., sample 4% of a sector, find 0 UXO, be 95% sure that the density is less than 0.1 per acre since, otherwise, at least one UXO would have been found).

3.4.4.3 Except for the Minimum Discrimination Module, all of the modules are variations on the same theme. The use of these modules is to statistically characterize the amount of UXO at a site either as a number per sector, a probability, or a density. The Minimum Discrimination Module is used to show that a sufficient amount of sampling has been performed. This module calculates the probability of finding at least one UXO within the sector for a given level of sampling when no UXO was found in the sector.

3.4.4.4 The results of the *UXO Calculator* application to the 312-acre and 11-acre parcels of the 323-acre wooded site at JPG are presented in Tables 3.5 and 3.6, respectively.

TABLE 3.5

UXO CALCULATOR APPLICATION RESULTS
312-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Sector Size (Acres)	312
Sampling Performed (Acres)	2.32
Number of UXO Recovered	1
Confidence Limit	90%
Maximum Potential UXO Density Per Acre	1.67

TABLE 3.6

UXO CALCULATOR APPLICATION RESULTS
11-ACRE PARCEL
JEFFERSON PROVING GROUND
MADISON, IN

Sector Size (Acres)	11
Sampling Performed (Acres)	0.5
Number of UXO Recovered	0
Confidence Limit	90%
Maximum Potential UXO Density Per Acre	4.45

3.5 POTENTIALLY HAZARDOUS OE ITEM DEMOLITION AND RECOVERED MATERIAL DISPOSAL

3.5.1 Potentially Hazardous OE Item Demolition Operation

3.5.1.1 One potentially hazardous OE item (a fuzed, practice 60mm mortar round) was found during the intrusive investigation conducted at the site. The OE item was destroyed in place. A description of this type of OE item is presented in Section 3.6.

3.5.1.2 The demolition operation of the potentially hazardous OE item was performed at the end of the day's field activities on May 10, 1999. The demolition operation consisted of a single shot. A jet perforator, NONEL (shock tube), and detonator cord were used in the operation. No secondary explosion was observed during the demolition operation, indicating that the potentially hazardous OE item did not contain any HE.

3.5.2 OE Scrap and Non-OE Related Scrap Recovery

3.5.2.1 In addition to the one potentially hazardous OE item destroyed in place, one piece of OE-related scrap was recovered from the site. The OE-related scrap item consisted of a spent 4.5-inch rocket motor. The OE-related scrap item was segregated, bagged, and relocated during the intrusive investigation to the on-site scrap yard designated for such items. Additionally, items recovered during the intrusive investigation that were non-OE-related were segregated from those that were OE-related. The Senior UXO Supervisor supervised this activity. Both the OE-related scrap and non-OE-related scrap were stored at the on-site scrap yard for disposal at the end of the field investigation.

3.5.2.2 Non-OE-related items recovered during the intrusive investigation included pieces of barbed wire, small metal nuggets, nails, fencing wire, a metal plate, horse shoes, an oil filter, a windshield wiper blade, and other miscellaneous metallic and non-metallic debris. All of the non-OE-related items were collected and stored at the on-site scrap yard for disposal at the end of the field investigation.

3.5.3 Off-Site Disposal

A total of 3.41 kg (7.5 lb.) of OE-related and non-OE-related scrap was transported to the JPG on-site scrap yard. The certificate of scrap is included in UXB's report of disposal

contained in Appendix D. UXB's USAESCH-approved Work Plan for the JPG OE clearance operation does not require the use of DD Form 1348-1. All metal scrap was sent to a local scrap dealer (Franklin Surplus of Hayden, Indiana) at the end of the project.

3.6 POTENTIALLY HAZARDOUS OE ITEM DESCRIPTION

3.6.1 Introduction

The results of the EE/CA field investigation performed at the site, as well as OE clearance operations conducted on other areas of JPG, reveal that a wide variety of OE items was used at the facility. The field investigations performed at the site confirmed the presence of UXO. The UXO item recovered from the site during this investigation was a practice 60mm mortar round. The following section briefly discusses the configuration, dimensions, major components, use, function, and other identifying characteristics of the 60mm mortar round.

3.6.2 60mm Mortar Round

3.6.2.1 The 60mm mortar round is fired from a tube and is designed to cause both personnel casualties and to destroy material. The effective range of the mortar varies from 303 meters (332 yards) to 1,809 meters (1,978 yards). The range of the mortar round is controlled by the number of propellant bags. The mortar is capable of a rate-of-fire of up to 30 rounds per minute. Each round is approximately 0.2441 meter (9.61 inches) long and 60mm (2.35 inches) in diameter and is capable of carrying a HE charge of either 0.42 pounds of Composition B or 0.34 pounds of TNT. The round destroyed at the site is assumed to have been a practice round as there was not a secondary explosion during its demolition. Because of the numerous models of this particular OE item, any fuzed 60mm mortar round found is assumed to be live and to contain HE and is, therefore, blown in place prior to any movement.

3.6.2.2 The practice round consists of a projectile body, an ignition cartridge, a point-detonating fuze, a fin assembly, propellant charge, and an inert filler. The projectile body is made of pearlitic malleable iron and is threaded internally at the nose to accept the fuze and at the base to accept the fin assembly. If the round had properly functioned when it was fired, the point-detonating fuze would have exploded on impact leaving only the projectile body and fin assembly. Figure 3-5 shows the components and dimensions of a 60mm mortar round.

3.7 POTENTIALLY HAZARDOUS OE ITEM SPATIAL ANALYSIS

An analysis was conducted of the location of the potentially hazardous OE item recovered from the 312-acre parcel compared to those potentially hazardous OE items recovered from the airfield site that is immediately east of the subject parcel. This analysis was conducted to determine whether there is a pattern to the recovery of the potentially hazardous OE items that would indicate a specific impact area where these items would be concentrated. This analysis revealed that there is no discernable pattern in the locations of the recovered potentially hazardous OE items. Figure 3-6 portrays the locations of the potentially hazardous OE items recovered from the 312-acre parcel and the adjacent airfield site.

FIGURE 3-5

60mm Mortar Round

FIGURE 3-6

Spatial Analysis of Recovered Potentially Hazardous OE Items